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(54) Beam shaping for optical scanners

(57) An optical scanner such as a bar code scanner includes a laser diode to create the scanning laser beam. Laser diodes are characteristically astigmatic, and when passed through a rotationally symmetric lens the beam typically forms a waist both in the x (scanning) direction and in the y (perpendicular) direction. The width of the beam envelope in the x direction is adjusted by means of a conventional lens. The width of the beam envelope in the y direction is adjusted by the use of a non-planar mirror, preferably a cylindrical mirror, as the rotating or oscillating element.

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Description

INTRODUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to optical scanners, and in particular to a scanner in which means are provided for shaping the scanning beam both in the direction of the scan and in the perpendicular direction.

2. Description of related art:

Optical scanners such as bar code scanners typically make use of light from laser diodes which is moved to provide the scanning beam. Such diodes are robust and relatively inexpensive, but they do suffer from the disadvantage that the beam emerging from a laser diode is astigmatic. The astigmatic laser diode can be characterized as having two apparent light sources spaced apart of each other along the optical path. One of the light sources lies in a horizontal plane, appears to be coming fr m inside the laser diode chip, and has a low angular divergence. The other apparent light source lies in a vertical plane, appears to be coming from a facet of the chip, and has a high angular divergence. These two apparent light sources, which are spaced apart from each other by typically about 20 micrometres, form two beam waists in different planes and in different directions, as measured relative to the planar junction of the chip.

A typical laser beam, showing these effects, is illustrated in Figure 6. In that Figure, a beam 34 is shown merging from a laser diode 33. The beam then passes through a focusing lens 32 and a shaping aperture 45 before impinging upon a surface 102 which carries a bar code symbol 100 to be read. As will be evident, the particular laser beam shown is asymmetric, with the shape of the beam cross-section depending upon distance from th light source **z**. At relatively small distances, such as **d1**, the beam is relatively wide in the **x** direction, the beam width gradually reducing with distance until the width becomes a minimum at distance **d3**. The width th n gradually starts to increase again at the greater distances **d4**, **d5** and **d6**. The beam is "waisted" in the **x** direction, with the "waist" occurring at approximately **d3**.

Similarly, the beam is likewise waisted in the **y** direction. At small distances such as **d1**, the height of the beam is relatively large. As the distance increases the height gradually reduces until the height reaches a minimum at approximately **d4**. At greater distances, such as **d5** and **d6** the height gradually increases again.

This example illustrates the fact that the **x** and **y** "waists" need not necessarily occur at the sam distance from the light source.

When a bar cod symbol is to be scanned (in the **x** direction) it is generally desirable for the beam width to be relatively small at the point at which it impinges upon the bar code symbol, to provide proper discrimination between the bars and spaces. On the other hand, it is desirable that the **y** dimension (perpendicular to the scanning direction) is relatively large to minimise problems due to noise. Typical noise includes the effects of laser speckle, incomplete printing of individual bars within the bar code symbol, and other printing artifacts such as the dots produced when a bar code symbol is printed out using a dot matrix printer.

Various approaches have been used in the past to mitigate the difficulties caused by the beam waist in the **y** direction. Canadian patent CA-A-1324442, in common ownership with the present application, teaches that under certain circumstances one need not compensate for laser astigmatism, but that one can instead use it for a positive purpose, that is to enhance visibility. Other prior art documents such as US-A-4,253,735 (Kawamura et al), US-A-5,081,639 (Snyder et al) and US-A-453,895 (Higgins et al) disclose that one can to some extent correct the astigmatism using appropriately shaped cylindrical lenses. This type of arrangement is however relatively expensive since additional costly optical elements are necessary. Furthermore, the additional optical elements must be very carefully and precisely mounted, thereby tending to increase manufacturing costs.

It is also known to provide some beam shaping in the **y** direction by providing an aperture stop in the beam. Although this is relatively inexpensive, it does not result in the desired aim of eliminating the **y**-direction "waist".

SUMMARY OF THE INVENTION

1. Objects of the invention

It is an objection of the present invention at least to alleviate the problems of the prior art.

It is a further object to provide a simple and inexpensive means of adjusting the beam profile (width at a particular distance from the light source) as desired in the **y** direction.

2. Features of the Invention

According to the present invention there is provided an optical scanner for scanning indicia comprising:

A housing;

Light source means within said housing for producing a light source beam, said light source beam having a first external envelope, said first external envelope having a cross section which varies with distance from said light source;

Scanning means mounted for scanning motion with respect to said housing, said scanning means being arranged to receive as input said sourc light beam and to produce as output a scanning light beam, said scanning light beam having a second external envelope, said second xternal nvelope having a cross section which varies with distance from said light source; and

said scanning light beam being caused by said scanning means to sweep across an indicia to be scanned, outside said housing; and

said scanning means including asymmetric beam shaping means whereby said first envelope of said source light beam is asymmetrically altered by said beam shaping means to said second envelope of said scanning light beam.

With an arrangement of this type, beam shaping is carried out by the rotating and/or oscillating scanning means, thereby obviating the need to have separate stationary asymmetric beam shaping elements such as additional cylindrical lenses. The stationary optical elements within the scanner can therefore be kept simple. In a preferred embodiment, the beam shaping means affects only the envelope of the beam in the y direction (perpendicular to the scanning or x direction), thereby enabling the designer to have effective independent control both of the x and y dimensions of the scanning laser spot at the expected working distance.

With the use of a conventional beam shaping element, such as a rotationally symmetric lens, in the beam, in addition to the arrangement defined above, both the x and y dimensions can easily be controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the X and Y beam profiles of a typical prior art scanner;

Figure 2 illustrates a typical prior art scanner giving rise to the beam profiles of Figure 1;

Figure 3 shows the preferred beam profiles as produced by a scanner embodying the present invention;

Figure 4 shows a scanner embodying the present invention and which produces the beam profiles shown in Figure 3; and

Figure 5 shows an exemplary hand-held scanner within which the embodiment of Figure 4 may be incorporated.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Details of a typical prior art bar code scanner are shown in Figure 2. A laser module 10 has a housing 11 within which is secured a laser diode 12 and a focusing lens 14. Light from the diode 12 passes through the lens 14 and emerges from the housing 11 via a beam shaping aperture 16 as an outgoing beam 18. The beam 18 impinges upon a rotating or oscillating scan mirror 20 from which it is reflected to form a scanning beam 21. Because of the oscillation or rotation of the mirror 20 the beam 21 scans back and fourth across an indicia to be read (not shown) in the direction of the arrows s. Light is reflected back from the indicia to a photodetector (not shown), the features of the indicia being determined by th changing output of the photodetector as the scanning beam 21 scans across the indicia.

Because of the astigmatism of the laser diode 12, the beam 18 and hence the scanning beam 21 is not entirely rotationally symmetric. Figure 1 shows how the x and y profiles of the beam vary with the distance (z) from the scanner. In this diagram, the x direction represents the scanning direction of the beam 21, and the y direction the direction mutually perpendicular to x and z. The line 22, in Figures 1 and 2, represents schematically the position of the nose or window of the optical scanner: accordingly, it will be understood that Figure 1 shows the profiles of the laser beam in the region outside the scanner.

The x profile shown in Figure 1 (b) may be controlled by altering the characteristics of the lens 14. The strength of the lens may be chosen so that the beam width in the x direction is optimised for the type of indicia to be scanned, and the expected distance (z) between the indicia and the scanner. The y beam profile, on the other hand, shown in Figure 1 (a) is primarily determined by the laser astigmatism and to some extent by the dimensions of the aperture 16. However, it is normally found in practice, depending upon the laser orientation, that the y profile has a smaller dimension (or "waist") somewhere within the working range. This is undesirable, since one generally wants to have a width in the y direction which is quite large (typically 1.5 to 2mm), to minimise the effects of noise.

Turning now to Figure 4, a scanning arrangement is shown which embodies the present invention. Corresponding reference numerals are used to those already used in Figure 2. In the embodiment of Figure 4, the plane scan mirror 20 is replaced by a shaped mirror 200, preferably a part-cylindrical mirror. The mirror 200 either oscillates or rotates to produce a shaped scanning laser beam 210.

The element 200 need not be a cylindrical mirror, but could instead be any other type of beam shaping means, mounted for rotation or oscillation, which is arranged to shape the beam asymmetrically in the x and y directions. The element 200 could, for example, be a rotationally asymmetric lens with appropriate other optical elements so that on rotation and/or oscillation the stationary laser beam 18 is converted into the shaped scanning beam 210.

The x and y profiles of the shaped beam 210 are shown in Figure 3. The x profile of Figure 3(b) is identical with the prior art x profile of Figure 1(b). However, the y profile is very different. By introducing the cylindrical scan mirror 200 the width of the beam in the y direction has been increased, and the "waist" eliminated entirely, or at least moved a long distance away in comparison with the expected working distance.

By a suitable choice of curvature for the mirror 200 the y beam profile can be adjusted as desired, independently of the x profile.

Figur 5 illustrates, as an example, a suitable type of hand-held laser scanner into which the present embodiment can be incorporated. The scanner comprises a main body 535 having a graspable hand portion

536 which carries a trigger 539. Within the body 535 is a laser module 515, which may for example be identical with the laser module 10 shown in Figure 4. Light from the laser module 515 is arranged to shine onto an oscillating mirror 510 (which is preferably a convex mirror such as the mirror 200 in Figure 4). The resulting beam 537 passes through a lens 512, and out of the housing via a window 538. The mirror 510 is arranged to oscillate in such a way that the beam 537 traces out a scan line 513 across an indicia 514 to be recorded. Light reflected back from the indicia passes through the window 538, is coll cted by a collecting mirror 526, and is reflected back to a photodetector 525. The optical signal is then converted into an electrical signal, and the features of the indicia 514 determined. In this exemplary embodiment, of course, the mirror 510 is profiled to provide y-axis beam shaping, and is preferably cylindrical.

While the invention has been illustrated and described with reference to one particular embodiment, it is not intended to be limited to any of the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the stand point of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalents of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set fourth in the appended claims. It should be noted that the objects and advantages of the invention may be attained by means of any compatible combination(s) particularly pointed out in the items of the following summary of the invention and the appended claims.

SUMMARY OF THE INVENTION

1. An optical scanner for scanning indicia comprising:

A housing;

Light source means within said housing for producing a light source beam, said light source beam having a first external envelope, said first external envelope having a cross section which varies with distance from said light source;

Scanning means mounted for scanning motion with respect to said housing, said scanning means being arranged to receive as input said source light beam and to produce as output a scanning light beam, said scanning light beam having a second external envelope, said second external envelope having a cross section which varies with distance from said light source; and

said scanning light beam being caused by said scanning means to sweep across an indicia to be scanned, outside said housing; and

said scanning means including asymmetric beam shaping means whereby said first envelope of said source light beam is asymmetrically altered by said beam shaping means to said second envelope of said scanning light beam.

2. An optical scanner wherein said beam shaping means is an aplanar mirror.

3. An optical scanner wherein said beam shaping means is a part-cylindrical mirror.

4. An optical scanner wherein said beam shaping means are mounted for rotation with respect to said housing.

5. An optical scanner wherein said beam shaping means are mounted for oscillation with respect to said housing.

6. An optical scanner wherein said scanning means is arranged to cause said scanning light beam repeatedly to sweep across the indicia in a scanning direction, said beam shaping means being arranged to broaden said second external envelope of said scanning light beam, with respect to said first external envelope of said light source beam, in a direction perpendicular to said scanning direction.

7. An optical scanner wherein said scanning means is arranged to cause said scanning light beam repeatedly to sweep across the indicia in a scanning direction, said beam shaping means being arranged to alter said second external envelope of said scanning light beam, with respect to said first external envelope of said light source beam, in a direction perpendicular to said scanning direction, but not to alter said second external envelope of said scanning light beam in a direction parallel to said scanning direction.

8. An optical scanner wherein said second external envelope of said scanning light beam in a direction perpendicular to said scanning direction has no waist.

9. An optical scanner wherein said second external envelope of said scanning light beam in a direction perpendicular to said scanning direction has no waist.

10. An optical scanner including rotationally-symmetric stationary beam shaping means positioned within said source light beam.

11. An optical scanner including stop means positioned within said source light beam.

12. An optical scanner wherein said first envelope of said source light beam is rotationally asymmetric.

13. An optical scanner wherein said first envelope of said source light beam is symmetric.

14. An optical scanner wherein said source light means comprises a laser.

15. An optical scanner wherein said laser is a laser diode.

Claims

1. An optical scanner for scanning indicia comprising:
A housing;
Light source means within said housing for producing a light source beam, said light source beam having a first external envelope, said first external envelope having a cross section which varies with distance from said light source;
Scanning means mounted for scanning motion with respect to said housing, said scanning means being arranged to receive as input said source light beam and to produce as output a scanning light beam, said scanning light beam having a second external envelope, said second external envelope having a cross section which varies with distance from said light source; and
said scanning light beam being caused by said scanning means to sweep across an indicia to be scanned, outside said housing; and
said scanning means including asymmetric beam shaping means whereby said first envelope of said source light beam is asymmetrically altered by said beam shaping means to said second envelope of said scanning light beam.

2. An optical scanner as defined in Claim 1 wherein said beam shaping means is an aplanar mirror, and
wherein preferably said beam shaping means is a part-cylindrical mirror.

3. An optical scanner as defined by Claim 1 wherein said beam shaping means are mounted for rotation with respect to said housing.

4. An optical scanner as defined by Claim 1 wherein said beam shaping means are mounted for oscillation with respect to said housing.

5. An optical scanner as defined by Claim 1 wherein said scanning means is arranged to cause said scanning light beam repeatedly to sweep across the indicia in a scanning direction, said beam shaping means being arranged to broaden said second external envelope of said scanning light beam, with respect to said first external envelope of said light source beam, in a direction perpendicular to said scanning direction.

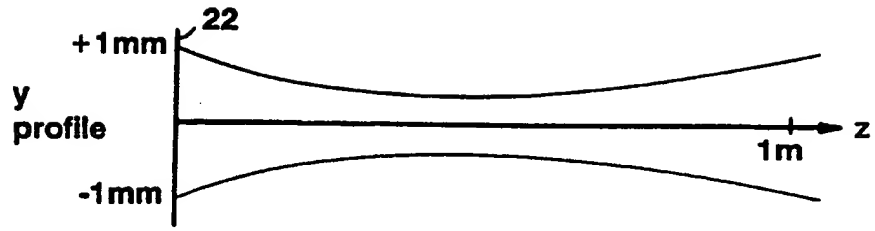
6. An optical scanner as defined by Claim 1 wherein said scanning means is arranged to cause said scanning light beam repeatedly to sweep across the indicia in a scanning direction, said beam shaping means being arranged to alter said second external envelope of said scanning light beam, with respect to said first external envelope of said light source beam, in a direction perpendicular to said scanning direction, but not to alter said second external envelope of said scanning light beam in a direction parallel to said scanning direction.

7. An optical scanner as defined by Claim 5 wherein said second external envelope of said scanning light beam in a direction perpendicular to said scanning direction has no waist.

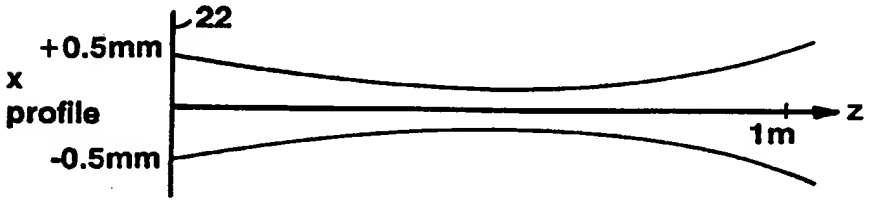
8. An optical scanner as defined by Claim 6 wherein said second external envelope of said scanning light beam in a direction perpendicular to said scanning direction has no waist.

9. An optical scanner as defined by Claim 1 including rotationally-symmetric stationary beam shaping means positioned within said source light beam,
preferably including stop means positioned within said source light beam,
wherein preferably said first envelope of said source light beam is rotationally asymmetric,
wherein preferably said first envelope of said source light beam is symmetric,
wherein preferably said source light means comprises a laser, and
wherein preferably said laser is a laser diode.

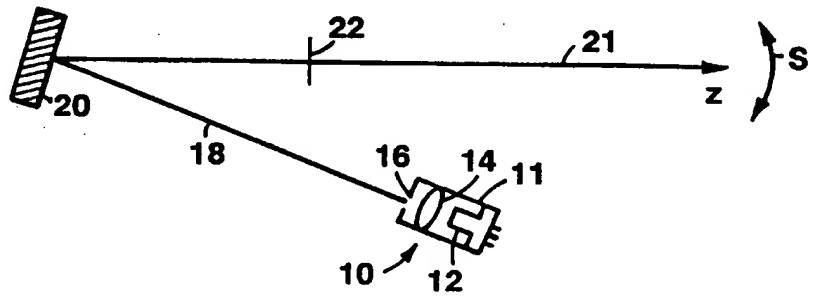
10. An optical scanner for scanning indicia comprising:
A housing;
Light source means within said housing for producing a light source beam;
Scanning means mounted for scanning motion with respect to said housing, said scanning means being arranged to receive as input said source light beam and to produce as output a scanning light beam; and
said scanning light beam being caused by said scanning means to sweep across an indicia to be scanned, outside said housing.



PRIOR ART
FIG. 1a



PRIOR ART
FIG. 1b



PRIOR ART
FIG. 2

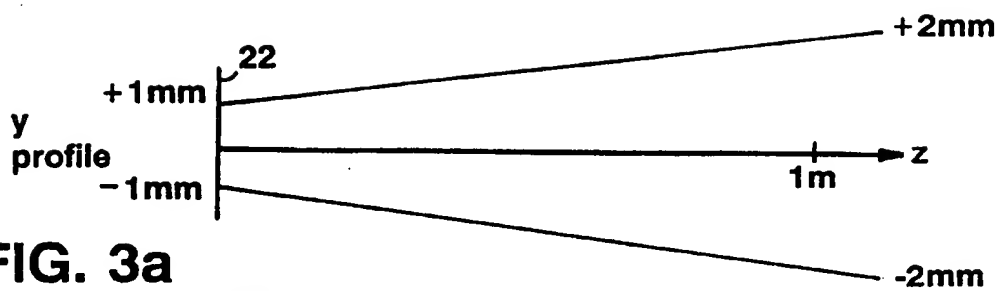


FIG. 3a

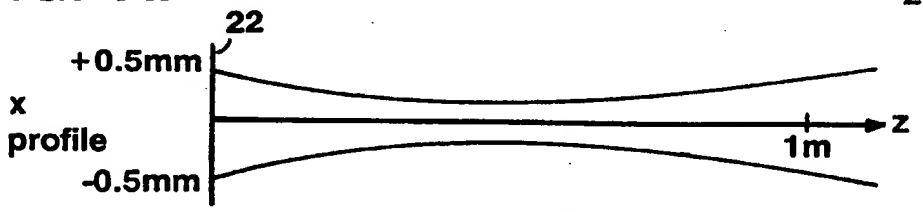


FIG. 3B

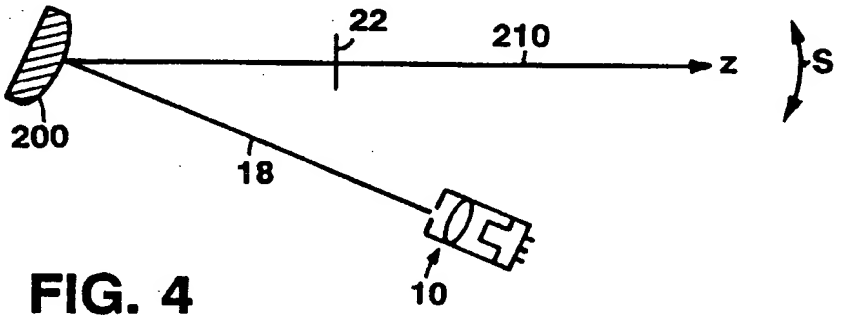


FIG. 4

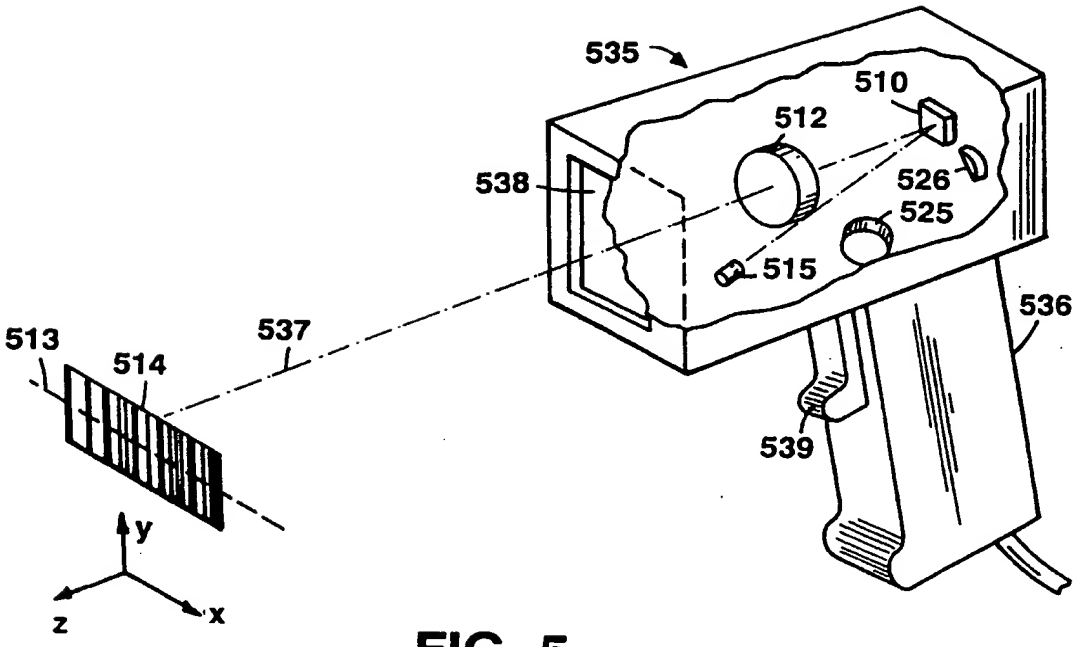


FIG. 5

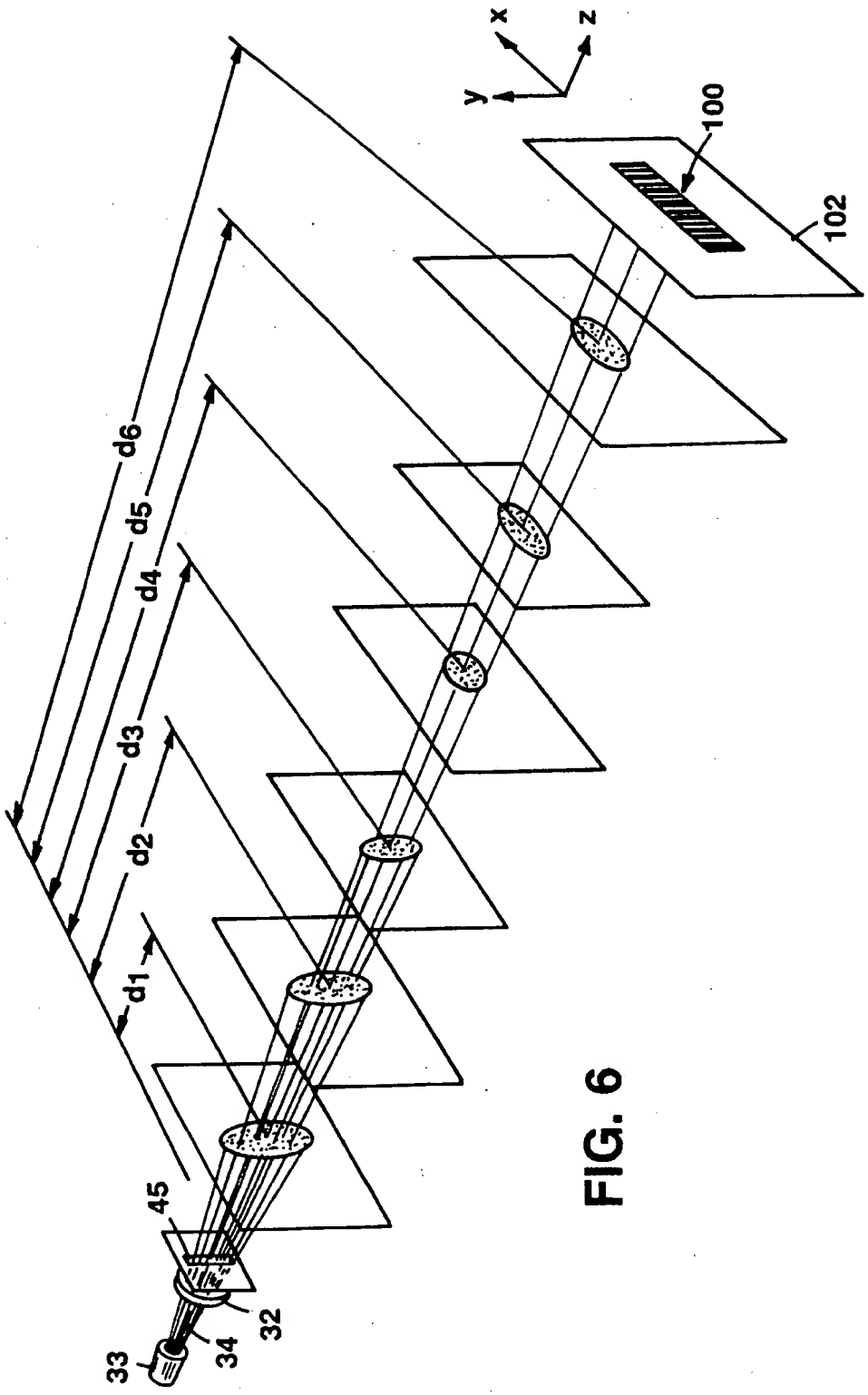


FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 0292

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 589 361 (SYMBOL TECHNOLOGIES INC) 30 March 1994 * column 6, line 47 - column 7, line 28 *	1,2,4	G06K7/10
A	EP-A-0 517 956 (SYMBOL TECHNOLOGIES INC) 16 December 1992 * column 8, line 57 - column 9, line 2; figure 11 * * column 11, line 6-16; figure 14 *	1,4,10	
A	US-A-5 136 147 (METLITSKY BORIS ET AL) 4 August 1992 * figures 1-5 *	1,4,10	
A	EP-A-0 230 892 (SICK OPTIK ELEKTRONIK ERWIN) 5 August 1987 * claims 3,4 *	2,3	
A	ELECTRONIC COMPONENTS AND APPLICATIONS, vol. 9, no. 2, 1 January 1989 pages 101-106, XP 000073926 CHALL P 'FOCUSING SEMICONDUCTOR LASER DIODES IN BARCODE READERS'		TECHNICAL FIELDS SEARCHED (Int.Cl.6) G06K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	12 October 1995	Fuchs, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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